TITLE OF THE INVENTION

AUTOFOCUS CONTROL APPARATUS AND METHOD

FIELD OF THE INVENTION

5   The present invention relates to an autofocus

control apparatus and method, and more specifically, to

an autofocus control apparatus and method which perform

focus control using image signals acquired by an image

sensing device that photoelectrically converts an

10   optical image of an object formed by an image sensing

optical system.

BACKGROUND OF THE INVENTION

Conventionally, there is an autofocus control

15   apparatus that performs focus control using image

signals acquired by an image sensing element that

photoelectrically converts an optical image of an

object formed by an image sensing optical system.

As such an autofocus control apparatus, there has

20   been proposed an autofocus control apparatus that uses

both an autofocus system employing contrast detection

and an autofocus system employing infrared ray

detection, and performs a focusing operation which uses

the autofocus system employing contrast detection at

25   the time of a normal image sensing operation and, on

the other hand, switches to the autofocus system

employing infrared ray detection only under an image

sensing environment in which the focusing operation according to the autofocus system employing contrast detection is difficult, to thereby perform a distance measurement operation and an autofocus operation with

5   respect to a desired subject. With such an apparatus, appropriate autofocus can be performed regardless of brightness of a subject (e.g., see Japanese Patent Laid-Open No. 5-119250).

In addition, as another autofocus control

10   apparatus, there has been proposed an autofocus control apparatus that uses both an autofocus system employing contrast detection, which photoelectrically converts an optical image of an object to generate image signals and detects a predetermined high-frequency component

15   from the generated image signals to thereby perform focusing, and an autofocus system using a light-emitting unit (LED) irradiating an infrared ray and infrared ray detection, which receives reflected light from an object to detect an output signal corresponding

20   to a distance to the object, and selects at least one of the autofocus system employing contrast detection and the autofocus system employing infrared ray detection on the basis of an output from a temperature detection device which detects environment temperature

25   to thereby perform an autofocus operation. According to this autofocus control apparatus, appropriate autofocus can be performed regardless of a change in

environment temperature when the apparatus is in use

(e.g., see Japanese Patent Laid-Open No. 2000-111792).

However, in the above-described conventional

examples, at least one of the autofocus system

5   employing contrast detection and the autofocus system

employing infrared ray detection is selected according

to brightness of a subject or environment temperature

when an apparatus is in use to perform an autofocus

operation.

10   Consequently, there is a disadvantage that it is

necessary to separately provide an autofocus device

employing infrared ray detection in addition to an

image sensing device for photoelectrically converting

an object image formed by an image sensing optical

15   system, which leads to an increase in cost. In

addition, in the case in which one of the autofocus

systems is selected to perform an autofocus operation,

there is a disadvantage that a high-speed and high-

precision autofocus operation cannot be performed.

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SUMMARY OF THE INVENTION

The present invention has been devised in view of

the above situation, and it is an object of the present

invention to realize a highly accurate autofocus

25   function at low cost.

According to the present invention, the foregoing

object is attained by providing an autofocus control

apparatus in an image sensing apparatus that comprises: an optical system including a focus lens; an image sensing unit that photoelectrically converts light incident via the optical system into image signals and

5   outputs the image signals; and a drive unit that drives the focus lens to adjust a focus position, the autofocus control apparatus comprising: a floodlighting unit; and a focus position detector that performs focus position detection according to an

10   active system and focus position detection according to a passive system on the basis of the image signals obtained from the image sensing unit.

According to the present invention, the foregoing object is also attained by providing an autofocus

15   control method in an image sensing apparatus that comprises: an optical system including a focus lens; an image sensing unit that photoelectrically converts light incident via the optical system into image signals and outputs the image signals; and a

20   floodlighting unit, the autofocus control method comprising: performing focus position detection according to an active system on the basis of the image signals obtained from the image sensing unit; and performing focus position detection according to a

25   passive system on the basis of the image signals obtained from the image sensing unit.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate
5   the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated
10   in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 is a block diagram showing a schematic
15   structure of an image sensing apparatus according to a first embodiment of the present invention;

FIG. 2 is a flowchart showing an image sensing operation of the image sensing apparatus according to the first embodiment of the present invention;
20   FIG. 3 is a flowchart explaining processing of active AF according to the first embodiment of the present invention;

FIG. 4 is a flowchart explaining object detection processing in the active AF according to the first
25   embodiment of the present invention;

FIG. 5 is a flowchart explaining the object detection processing in the active AF according to the first embodiment of the present invention;

FIG. 6 is a diagram showing an example of arrangement of color filters;

FIG. 7 is a flowchart explaining processing of scan AF according to the embodiment of the present invention;

FIG. 8 is a diagram showing a relation between an amount of high-frequency component and a focus lens position at the time when the scan AF is executed according to the embodiment of the present invention;

FIG. 9 is a flowchart explaining object detection processing in active AF according to a second embodiment of the present invention;

FIG. 10 is a flowchart explaining object detection processing in the active AF according to the second embodiment of the present invention;

FIG. 11 is a flowchart explaining object detection processing in active AF according to a third embodiment of the present invention;

FIG. 12 is a flowchart showing a flow of an operation of active AF according to a fourth embodiment of the present invention;

FIG. 13 is a block diagram showing a schematic structure of an image sensing apparatus according to a fifth embodiment of the present invention; and

FIG. 14 is a flowchart showing a flow of an operation of active AF according to the fifth embodiment of the present invention.

5   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will be described in detail in accordance with the accompanying drawings.

[First embodiment]

10   FIG. 1 is a block diagram showing an example of a schematic structure of an image sensing apparatus according to a first embodiment of the present invention. The image sensing apparatus includes, for example, a digital still camera and a digital video

15   camera but is not limited to these cameras. It is possible to apply the present invention to any image sensing apparatus as long as the image sensing apparatus acquires an incident optical image as an electrical image by photoelectric conversion using a

20   solid-state image sensing device, such as an area sensor, whose pixels are arranged two-dimensionally.

In FIG. 1, reference numeral 1 denotes an image sensing apparatus; 2, a group of zoom lenses; 3, a group of focus lenses; 4, a stop serving as a light

25   amount adjusting unit and an exposure unit that controls an amount of light beams transmitted through an image sensing optical system including the group of

zoom lenses 2, the group of focus lenses 3, and the
like; 31, a lens-barrel including the group of zoom
lenses 2, the group of focus lenses 3, the stop 4, and
the like; 5, a solid state image sensing device such as

5   a CCD (hereinafter referred to as "CCD") on which an
image of an object transmitted through the image
sensing optical system is formed and that
photoelectrically converts the transmitted image; 6, an
image sensing circuit that receives electric signals

10   photoelectrically converted by the CCD 5 and applies
various kinds of image processing to the electric
signals to thereby generate image signals of a
predetermined form; 7, an A/D conversion circuit that
converts analog image signals generated by the image

15   sensing circuit 6 into digital image signals; 8, a
memory such as a buffer memory (VRAM) that temporarily
stores the digital image signals outputted from the A/D
conversion circuit 7; 9, a D/A conversion circuit that
reads out image signals stored in the VRAM 8 to convert

20   the image signals into analog signals and converts the
same into image signals of a form suitable for
reproduction and output; 10, an image display device
such as a liquid crystal display device (LCD)
(hereinafter referred to as LCD) that displays the

25   image signals; 12, a storage memory, which stores image
data, comprising a semiconductor memory or the like;
and 11, a compression/expansion circuit including a

compression circuit, which reads out the image signals temporarily stored in the VRAM 8 and applies compression processing and coding processing of image data in order to change the image signals to a form

5   suitable for storage in the storage memory 12, and an expansion circuit, which applies decoding processing and expansion processing for changing the image data stored in the storage memory 12 to a form optimal for performing reproduction, display, and the like of the

10   image data.

In addition, reference numeral 13 denotes an AE processing circuit that receives an output from the A/D conversion circuit 7 and performs automatic exposure (AE) processing; 14, a scan AF processing circuit that

15   receives an output from the A/D conversion circuit 7 and performs autofocus (AF) processing; 15, a CPU incorporating a memory for arithmetic operation for controlling the image sensing device; 16, a timing generator (hereinafter referred to as TG) that

20   generates a predetermined timing signal; 17, a CCD driver; 21, a stop drive motor that drives the stop 4; 18, a first motor drive circuit that controls to drive the stop drive motor 21; 22, a focus drive motor that drives the group of focus lenses 3; 19, a second motor

25   drive circuit that controls to drive the focus drive motor 22; 23, a zoom drive motor that drives the group

of zoom lenses 2; and 20, a third motor drive circuit
that controls to drive the zoom drive motor 23.

Moreover, reference numeral 24 denotes an
operation switch including various groups of switches;
5   25, an EEPROM serving as an electrically writable read-
only memory in which a program for performing various
kinds of control, data to be used for causing the
apparatus to perform various operations are stored in
advance; 26, a battery; 28, an electronic flash; 27, a
10   switching circuit that controls emission of flash of
the electronic flash 28; 30, a light-emitting section
for irradiating a light beam of infrared rays to an
object including a floodlighting lens and a light-
emitting device such as a light-emitting diode; 32, an
15   iR cut filter that blocks an infrared ray; and 33, a
filter drive circuit for inserting and retracting the
iR cut filter 32 in front of the CCD 5.

Note that, as the storage memory serving as a
storage medium for image data and the like, various
20   forms of memories may be applied. Those include, *inter
alia*, a stationary semiconductor memory such as a flash
memory, a semiconductor memory such as a card type
flash memory that is formed in a card shape or a stick
shape and is formed to be detachable attachable to the
25   apparatus, and a magnetic storage medium such as a hard
disk or a floppy disk.

As the operation switch 24, there are a main power supply switch for starting the image sensing apparatus 1 and supplying power, a release switch that starts an image sensing operation (storage operation), a

5 reproduction switch that starts a reproduction operation, a zoom switch that instructs to move the group of zoom lenses 2 of the image sensing optical system to perform zooming.

The release switch is constituted by two step

10 switches including a first stroke (hereinafter referred to as SW1), which generates an instruction signal for starting AE processing and AF processing to be performed prior to an image sensing operation, and a second stroke (hereinafter referred to as SW2), which

15 generates an instruction signal for starting an actual exposure operation.

Next, an operation of the image sensing apparatus in the first embodiment having the above-described structure will be described.

20 First, a light beam from an object, which has been transmitted through the groups of lenses 2 and 3 in the lens-barrel 31 of the image sensing apparatus 1, is formed on a light-receiving surface of the CCD 5 after a light amount thereof is adjusted by the stop 4. This

25 optical image of the object is converted into electric signals by photoelectric conversion processing by the CCD 5 to be outputted to the image sensing circuit 6.

The image sensing circuit 6 applies various kinds of
signal processing to the inputted signals to generate
image signals. These image signals are outputted to
the A/D conversion circuit 7 and converted into digital
5   signals (image data), and then temporarily stored in
the VRAM 8.

The image data stored in the VRAM 8 is outputted
to the D/A conversion circuit 9, converted into analog
signals, and converted into image signals of a form
10   suitable for display, and is then displayed as an image
on the LCD 10. On the other hand, the image data
stored in the VRAM 8 is also outputted to the
compression/expansion circuit 11. After subjected to
compression processing by the compression circuit in
15   the compression/expansion circuit 11, the image data is
converted into image data of a form suitable for
storage and stored in the storage memory 12.

In addition, for example, when a not-shown
reproduction switch in the operation switch 24 is
20   turned on, a reproduction operation is started. Then,
the image data, which is stored in the storage memory
12 in the compressed form, is outputted to the
compression/expansion circuit 11 and subjected to
decoding processing, expansion processing, or the like
25   in the expansion circuit, and is then outputted to the
VRAM 8 to be temporarily stored. Moreover, this image
data is outputted to the D/A conversion circuit 9 and

converted to analog signals, and converted into image signals of a form suitable for display, and is then displayed as an image on the LCD 10.

On the other hand, the image data digitized by the
5   A/D conversion circuit 7 is also outputted to the AE processing circuit 13 and the scan AF processing circuit 14 when being outputted to the VRAM 8. In the AE processing circuit 13, in response to the inputted digital image signals, arithmetic operation processing
10 such as cumulative addition and the like is applied to a luminance value of image data of one frame. Consequently, an AE evaluation value corresponding to brightness of the subject is calculated. This AE evaluation value is outputted to the CPU 15.

15   In the scan AF processing circuit 14, in response to the inputted digital image signals, a high-frequency component of image data of one frame is extracted via a high-pass filter (HPF) or the like, and arithmetic operation processing such as cumulative addition or the
20 like is further performed. Consequently, an AF evaluation value corresponding to an amount of contour component on a high-frequency side is calculated. In this way, the scan AF processing circuit 14 acts as a part of a high-frequency component detection unit which
25 detects a predetermined high-frequency component from the image signals generated by the CCD 5 in a course of performing the AF processing.

A predetermined timing signal is outputted to the
CPU 15, the image sensing circuit 6, and the CCD driver
17 from the TG 16, and the CPU 15 performs various
kinds of control in synchronization with this timing
5   signal. In addition, in response to the timing signal
from the TG 16, the image sensing circuit 6 performs
various kinds of image processing such as color signal
separation or the like in synchronization with the
timing signal. Moreover, in response to the timing
10   signal from the TG 16, the CCD driver 17 drives the CCD
5 in synchronization with the timing signal.

The CPU 15 controls the first motor drive circuit
18, the second motor drive circuit 19, and the third
motor drive circuit 20, respectively, to thereby
15   control to drive the stop 4, the group of focus lenses
3, and the group of zoom lenses 2 via the stop drive
motor 21, the focus drive motor 22, and the zoom drive
motor 23. In other words, the CPU 15 controls the
first motor drive circuit 18 on the basis of the AE
20   evaluation value or the like calculated in the AE
processing circuit 13 to drive the stop drive motor 21
and performs AE control for adjusting the stop 4 such
that a stop value becomes appropriate. Further, the
CPU 15 performs AF control for controlling the second
25   motor drive circuit 19 on the basis of the AF
evaluation value calculated by the scan AF processing
circuit 14 and an output obtained by an active AF unit

to be described later to drive the focus drive motor 22
and move the group of focus lenses 3 to a focus
position. In the case in which a not-shown zoom switch
in the operation switch 24 is operated, in response to
5 the operation, the CPU 15 controls the third motor
drive circuit 20 to drive the zoom motor 23 to thereby
move the group of zoom lenses 2 and perform a
magnification operation (zoom operation) of the image
sensing optical system.

10   Next, an image sensing operation of the image
sensing apparatus 1 will be described using a flowchart
shown in FIG. 2.

    When a main power switch of the image sensing
apparatus 1 is ON and an operation mode of the image
15 sensing apparatus 1 is in an image sensing (recording)
mode, an image sensing processing sequence is executed.

    First, in step S1, as described above, the CPU 15
displays an optical image of an object, which is
transmitted through the lens-barrel 31 and formed on
20 the CCD 5, as an image on the LCD 10 via the image
sensing circuit 6, the A/D conversion circuit 7, the
VRAM, and the D/A conversion circuit 9.

    Subsequently, in step S2, the CPU 15 confirms a
state of the release switch. When the release switch
25 is operated by a user and the CPU 15 confirms that the
SW1 (first stroke of the release switch) is turned ON,
the CPU 15 proceeds to the next step S3, and normal AE

processing is executed. Then, in step S4, the CPU 15 performs active AF processing. The active AF processing is for detecting a rough distance to a desired object (focus position of the group of focus

5   lenses 3) and is AF processing so-called coarse adjustment. The active AF processing will be described in detail later.

    After the active AF processing, in step S5, the CPU 15 performs scan AF processing (or passive AF) for

10 fine tuning for detecting an accurate focus position. In the scan AF processing, the CPU 15 performs the fine tuning for detecting an accurate focus position while moving the group of focus lenses 3 within a predetermined range around a found focus position.

15 Details of the scan AF processing will also be described later.

    When the predetermined AF processing ends in this way, in step S6, the CPU 15 confirms the state of the SW2 (second stroke of the release switch). If the SW2

20 is ON, the process proceeds to step S7 and the CPU 15 executes actual exposure processing. Then, in step S8, the CPU 15 stores an image obtained by exposure in the storage memory 12 via the CCD 5, the image sensing circuit 6, the A/D conversion circuit 7, the VRAM 8,

25 and the compression/expansion circuit 11 as described above.

Next, details of the active AF processing executed
in step S4 will be described with reference to FIG. 3.

First, in step S20, the CPU 15 drives the filter
drive circuit 33 to retract the iR cut filter 32 from

5   the front of the CCD 5 so as not to attenuate an
infrared ray component that is attenuated at the time
of image sensing. This is because an infrared light-
emitting device is used as a light-emitting section 30
for the active AF processing since reflectance of an

10   infrared ray on various objects is more stable than a
normal ray and good distance measurement can be
expected.

Subsequently, in step S21, the CPU 15 performs
charge accumulation with the light-emitting section 30

15   on. The CPU 15 causes the light-emitting section 30 to
emit light to irradiate an infrared ray to the object.
At the same time, the CPU 15 adjusts an amount of light
to be received by the CCD 5 with the stop 4. More
specifically, the CPU 15 performs control such that the

20   stop 4 is narrowed and an amount of light emission of
the light-emitting section 30 is increased when it is
bright and the stop 4 is opened and the amount of light
emission of the light-emitting section 30 is reduced
when it is dark. The incident optical image of the

25   object is converted into electric signals by the
photoelectric conversion processing of the CCD 5 and
outputted to the image sensing circuit 6.

Next, in step S22, the CPU 15 controls the image
sensing circuit 6 and reads out only a part of the
output signals corresponding to a central part of the
CCD 5 (hereinafter referred to as "detection area").

5   Then, in step S23, after outputting the read-out output
signals to the A/D conversion circuit 7 and converting
it into digital signals (image data), the CPU 15 stores
the digital signals in a memory incorporated therein.
The digital signals are stored in the memory

10   incorporated in the CPU 15 because an amount of data is
small, since only a part of the image data from the CCD
5 has to be stored here. In addition, high-speed
processing can also be realized by reading out only the
part of the image data in this way.

15   Then, the process proceeds to step S24 and the CPU
15 performs charge accumulation with the light-emitting
section 30 off with the same stop as at the time of the
charge accumulation with the light-emitting section 30
on in step S21. The optical image of the object formed

20   on the light receiving surface of the CCD 5 is
converted into electric signals by the photoelectric
conversion processing of CCD 5 and outputted to the
image sensing circuit 6 (step S25). The image sensing
circuit 6 applies various kinds of signal processing to

25   the inputted signal to generate image signals. The
image signals are outputted to the A/D conversion
circuit 7 and converted into digital signals (image

data), and are then temporarily stored in the VRAM 8

(step S26). Then, the digital signals are outputted to

the D/A conversion circuit 9, converted into analog

signals, and converted into image signals of a form

5   suitable for display, and are then displayed as an

image on the LCD 10.

The process proceeds to step S27 and the CPU 15

performs an external light eliminating operation. Here,

the CPU 15 finds differences between image data of the

10   charge accumulation with the light-emitting section 30

on and image data of the charge accumulation with the

light-emitting section 30 off to thereby find data

(object) of a reflected image that is obtained as the

infrared ray irradiated by the light-emitting section

15   30 is reflected on the object. Since a component of an

image formed by external light can be removed, it

becomes easy to find a center of the reflected image.

Practically, the CPU 15 reads data of a part

corresponding to the image data stored in the memory

20   incorporated in the CPU 15 among the image data stored

in the VRAM 8 and calculates differences between the

read image data and the image data stored in the memory

incorporated in the CPU 15 to thereby remove external

light components. An arithmetic operation result

25   (differential data) with the external light eliminated

in this way is stored in the memory incorporated in the

CPU 15.

Subsequently, in step S28, the CPU 15 calculates a center of gravity of the reflected image using the differential data calculated in step S27. Here, the CPU 15 extracts an object with a relatively high luminance having steep leading and trailing edges in the differential data and finds a center of gravity of the extracted object.

Detection of an object is performed using signal values of one line that are found by adding a plurality of lines of differential data. Note that, in the case in which the surface of the CCD 5 is covered by a color filter for color separation, only signal values corresponding to a color filter with highest sensitivity to an infrared ray (red in a primary color filter) are used. Consequently, since it becomes unnecessary to correct sensitivity of each color component of a color filter for an infrared ray as in the case in which all pixels are used, uncertainty due to sensitivity correction can be avoided and processing can be performed at high speed.

Here, details of the processing for finding a center of gravity of an object performed in step S28 will be described with reference to FIGS. 4 and 5.

First, in step S400, the plurality of lines of differential data are merged into one line.

Here, in the case in which a filter color arrangement for color separation covering the CCD 5 is

a color arrangement as shown in FIG. 6, pixels
corresponding to red are arranged in every other row
and in ever other pixel. Thus, the plurality of lines
are merged into one line as described below.

5   First, a differential data value of a j-th pixel
of an L-th row is represented as a[L, j]. In addition,
it is assumed that an i-th signal value of data for
object detection arranged in one line is d[i]. In the
case in which a positional relation between a detection

10   area of the CCD 5 read in step S22 (area indicated by
hatch lines in FIG. 6) and a filter arrangement are as
shown in FIG. 6, since a filter corresponding to red
exists in in odd number pixels of odd number rows, d[i]
can be represented as

15       $d[i] = \sum_{m} a[2m - 1, 2i - 1]$.

A range of m is from 1 to 1/2 of the number of rows in
the detection area (decimals are raised to the next
whole number). In other words, addition is performed
from a first row (m=1) until the number of 2m-1 becomes

20   equal to the number of the detection area (in the case
in which the number of rows is an odd number) or to the
number of rows of the detection area - 1 (in the case
in which the number of rows is an even number). In
addition, a range of i is from 1 to 1/2 of the number

25   of pixels in a horizontal direction of the detection
area (decimals are raised to the next whole number).
In other words, addition is performed from a first

pixel (i=1) until 2i-1 becomes equal to the number of
pixels in the horizontal direction of the detection
area (in the case in which the number of pixels is an
odd number) or to the number of pixels of the detection

5   area -1 (in the case in which the number of pixels is
an even number).

For example, in the case in which seven rows form
the detection area in the active AF as shown in FIG. 6,
a first pixel of added lines into a single line is

10 represented as follows:

$$d[1] = a[1,1]+a[3,1]+a[5,1]+a[7,1].$$

In this way, data obtained by external light
elimination stored in the incorporated memory is merged
into data of a single line, and the detection of an

15 object is performed after storing the result of merging
the data (hereinafter referred to as "line differential
data").

Note that the above arithmetic equations are
applied to the case shown in FIG. 6 and is required to

20 be changed appropriately according to an arrangement of
color filters or a position of a detection area on the
CCD 5.

Next, in step S401, the CPU 15 performs
initialization of variables used in an arithmetic

25 operation and initialization of a work area of a memory.
Here, the CPU 15 clears a work area in which counters i
and k and data of an object are to be stored. In

addition, since a plurality of objects may be detected, a plurality of memory areas for an arithmetic operation are prepared in which data of the objects is stored.

Next, in step S402, the CPU 15 reads out the line

5 differential data stored in the memory incorporated in the CPU 15 in order. Here, each data is represented as d[i]. Then, in step S403, the CPU 15 compares d[i] with a first threshold value Th1. If d[i] is equal to or more than the first threshold value Th1, in step

10 S404, the CPU 15 calculates a difference between d[i] and line differential data of a pixel that is away from the pixel of d[i] by a plurality of pixels (e.g., two pixels), and checks if the difference is equal to or more than a second threshold value Th2. If the

15 difference is equal to or more than the second threshold value Th2, since it can be judged as a leading edge of an object (i.e., a left end of the object), the process proceeds to step S405 and various data of this object is stored in the memory

20 incorporated in the CPU 15. Consequently, an object with a relatively high luminance having steep leading edge has been detected. On the other hand, if the condition is not satisfied in step S403 or S404, the process proceeds to step S416 in FIG. 5.

25 In step S405, the CPU 15 finds a sum of luminance d[i] of signals and a sum of products of luminance of signals and coordinates, d[i] × i, as data of the·

object and stores the sums. In addition, the CPU 15

stores i as L[k] as the coordinate of the left end of

the object. Now, when it is assumed that a sum of

luminance of a k-th object is Sd[k] and a sum of

5   products of luminance and coordinates is Se[k], the

following equations are used.

     Sd[k] = d[i]+d[i-1]

     Se[k] = d[i]×i+d[i-1]×(i-1)

     Next, in step S406, the CPU 15 increments the

10   counter i by one to set the next pixel as a subject of

processing. In the next step S407, the CPU 15 judges

if the processing has been finished for all the pixels

of the line differential data. If the processing has

been finished, the process proceeds to step S411, and

15   if the processing has not been finished, the process

proceeds to step S408. In step S408, the CPU 15 reads

out the next line differential data d[i]. Then, in

step S409, the CPU 15 compares d[i] with the first

threshold value Th1. If d[i] is equal to or more than

20   the first threshold value Th1, the CPU 15 judges that

the object still continues, and proceeds to step S410

and updates the data of the object in accordance with

the following equations.

     Sd[k] = Sd[k]+d[i]

25   Se[k] = Se[k]+d[i]×i

     The CPU 15 performs these processes for updating

data of the object until the condition of step S409 are

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not satisfied while updating the counter i in step S406.
However, if the detection for all the pixels is
finished while these processes are continued (YES in
step S407), since the condition of trailing edge is not

5   satisfied, the CPU 15 judges that the object currently
detected is inappropriate, clears the data of the
object in step S411, and the process immediately
proceeds to step S418.

        If the condition of step S409 is not satisfied (if

10 d[i] is not equal to or more than the first threshold
value Th1), since it can be judged that the object has
ended, the CPU 15 checks whether or not the object has
a steep trailing edge. In step S412, the CPU 15
calculates a difference between d[i] and line

15 differential data of a pixel that is away from the
pixel of d[i] by a plurality of pixels (e.g., two
pixels), finds inclination at the trailing edge of the
object, and checks if the declination is equal to or
more than the second threshold value Th2. If the

20 declination at the trailing edge of the object is equal
to or more than the second threshold value Th2, since
an object with a relatively high luminance having steep
leading and trailing edges has been extracted, the
process proceeds to step S413 and the CPU 15 updates

25 the data of the object in accordance with the following
equations.

        Sd[k] = Sd[k]+d[i]

Se[k] = Se[k]+d[i]×i

Moreover, the CPU 15 stores i in R[k] as the coordinate of the right end of the object. Then, the CPU 15 increments the counter k by one (step S414) and

5 updates an address of the memory storing the data of the object. On the other hand, if the condition is not satisfied in step S412, since an object with a relatively high luminance having steep leading and trailing edges has not been extracted, the CPU 15

10 clears the data of the object that has been stored to that point (step S415).

Then, the process proceeds to step S416 and the CPU 15 increments the counter i by one to set the next pixel as a subject of an arithmetic operation, and then,

15 in step S417, checks whether or not detection for all the pixels has been finished.

If the detection for all the pixels has been finished, in step S418, the CPU 15 finds a center of gravity of the detected object. The coordinate Px of

20 the center of gravity of the object is calculated as follows.

Px = Se[k]/Sd[k]

When a plurality of objects have been detected, the CPU 15 selects object/objects for which R[k]-L[k]

25 is within a predetermined range. This is because, since a size of a reflected image of a light-emitting section 30 on the CCD 5 should be substantially fixed,

only reflected image/images falling within a fixed range anticipating an error is/are considered to be correct reflected image/images of the light-emitting section 30. In the case in which a plurality of

5   objects still remain, an object for which a value of Sd[k]/(R[k]-L[k]) is the largest is selected. This is because, since the external light elimination has been performed for the object, it is considered that a luminance of a reflected image of a light-emitting

10   section 30 becomes the maximum.

After finding the center of the gravity of the reflected image in step S28 of FIG. 3 as described above, in step S29, the CPU 15 finds a distance to the object to be sensed on the basis of a position of the

15   center of gravity. A distance L to the object is found as follows based on the principle of triangulation:

$$L = (f+\Delta z) \times B/x.$$

Here, f is a focal length of an image sensing lens, Δz is an extension amount of the image sensing lens, B is

20   a baseline length (interval between an optical axis of the light-emitting section 30 and an optical axis of the image sensing lens), and x is a deviation amount from a center of an optical axis of the reflected image. Then, the CPU 15 finds a value indicating a position of

25   the group of focus lenses 3 corresponding to this distance L and sets it as a focus position G1 of the active AF.

In addition, if a center of gravity of the reflected image is not found in step S28, since it is anticipated that the object is in the distance and an intensity of the reflected image is small, the CPU 15
5   sets a starting point of a detection operation for a focus position by the scan AF processing to infinity and sets a focus position of the active AF as a value found by subtracting a variable Gs from infinity.

Note that it is also possible to repeat the
10 processing from steps S21 to S29 plural times and set an average of the obtained focus positions as a focus position of the active AF.

Thereafter, the process proceeds to step S30 and the CPU 15 inserts the iR cut filter 32, which has been
15 retracted from the front of the CCD 5 in step S20, in front of the CCD 5 again.

Then, as described above, in step S5, the CPU 15 moves the group of focus lenses 3 to the vicinity of the focus position which has been found as a result of
20 the distance measurement of the active AF processing.

Next, details of the scan AF executed in step S5 of FIG. 2 will be described.

FIG. 7 is a flowchart showing processing of the scan AF. FIG. 8 shows a relation between an amount of
25 high-frequency component and a focus lens position at the time when the scan AF is executed.

In step S51 of FIG. 7, using the result of the
arithmetic operation of the active AF processing, the
CPU 15 sets a start position and a stop position for
driving the group of focus lenses 3 in order to perform
5   a detection operation of a focus position by the scan
AF processing. A value of the start position set here
is found by subtracting a variable Gs from the focus
position obtained by the active AF (a value indicating
the position of the group of focus lenses 3
10   corresponding to the distance to the object as the
result of the arithmetic operation of the active AF
processing) G1. In addition, a value of the stop
position is found by adding the variable Gs to the
focus position G1 obtained by the active AF. In other
15   words, a range in which the scan AF is executed is a
predetermined range around the position corresponding
to the distance to the object according to the result
of the arithmetic operation of the active AF processing.
Note that the start position may be found by adding the
20   variable Gs to G1 and the stop position may be found by
subtracting the variable Gs from G1. In which case, a
driving direction of the group of focus lenses 3 is
opposite to that in the case in which the values set in
step S51 are adopted.
25   In addition, this variable Gs is determined taking
into account a focal length of the image sensing lens,
the result of the arithmetic operation of the active AF

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processing (distance to the object), parallax, a distance measurement error anticipated in the active AF processing, and the like.

In general, a focusing operation in an image 5 sensing apparatus is an operation for focusing light beams from a desired object, which are converged by an image sensing optical system, on an image sensing surface (light-receiving surface) of an image sensing device (CCD, etc.). Therefore, the group of focus 10 lenses 3, which are a part of the image sensing optical system, are moved in an optical axis direction to obtain the focused state. An amount of the movement in the optical axis direction tends to increase as the object is closer to the image sensing apparatus. In 15 addition, the amount of the movement tends to increase as a focal length of the image sensing lens is longer.

Further, the parallax also tends to increase as the object is closer to the image sensing apparatus and the focal length of the image sensing lens is longer.

20 Therefore, the variable Gs determining a range of the scan AF has a larger value as the distance to the object obtained from the result of the arithmetic operation of the active AF processing is closer and the focal length of the image sensing lens is longer.

25 The distance measurement error includes, *inter alia*, an adjustment error at the time of manufacturing the image sensing apparatus, a temperature error such

as distortion caused by an environmental temperature change of the lens-barrel 31, a distance measurement error due to a mechanical error of constituent members (the CCD 5, the light-emitting section 30, etc.) for

5 performing the active AF, a movement error of the group of focus lenses 3, and the like are possible.

Therefore, the variable Gs is set to a value found from the distance to the object obtained from the result of the arithmetic operation of the active AF

10 processing and the focal length of the image sensing lens taking into account the distance measurement error.

For example, the variable Gs can be found by the following expression. Here, K1 is a constant, L is the distance to the object, f is the focal length of the

15 image sensing lens, and δL is a coefficient for a distance measurement error or the like.

Gs = K1×f/L+δL

Subsequently, in step S52, the CPU 15 drives the focus motor 22 via the second motor drive circuit 19

20 and moves the group of focus lenses 3 to the start position set in step S51. Then, the CPU 15 executes the scan AF processing for finding a focus position while moving the group of focus lenses 3 with the start point as the origin at a predetermined amount of

25 movement.

In step S53, the CPU 15 judges whether or not the group of focus lenses 3 have reached the end position

set in step S51. If the group of focus lenses 3 have
not reached the end position, the CPU 15 controls the
CCD 5 and the like to acquire image data corresponding
to a position of the group of focus lenses 3 at that

5 point. This image data is outputted to the scan AF
processing circuit 14 via the image sensing circuit 6
and the A/D conversion circuit 7, and an AF evaluation
value is calculated in step S54. This AF evaluation
value is outputted to the CPU 15 and stored in the

10 memory for arithmetic operation incorporated in the CPU
15. In the next step S55, the CPU 15 moves the group
of focus lenses 3 by a predetermined amount.
Thereafter, the CPU 15 returns to step S53 and repeats
the same processing until the group of focus lenses 3

15 reaches the set end position.

      Then, when it is judged in step S53 that the group
of focus lenses 3 has reached the end position, the
process proceeds to step S56. In step S56, the CPU 15
performs an arithmetic operation of a focus position on

20 the basis of the AF evaluation value calculated in step
S54. Then, on the basis of a result of the arithmetic
operation, in step S57, the CPU 15 drives the focus
motor 22 via the second motor drive circuit 19 to move
the group of focus lenses 3 to the focus position.

25 When the group of focus lenses 3 stops in this position,
the CPU 15 ends the series of sequences. Thereafter,
the CPU 15 proceeds to step S6 of FIG. 2.

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The series of operations in the san AF processing
will be hereinafter described with reference to FIG. 8.

For example, in a state in which the group of
focus lenses 3 are in a position indicated by A in FIG.
5   8, the group of focus lenses 3 first move from the
position of A to a position B found by subtracting Gs
from a result of distance measurement of the active AF
that is the start position (step S52). With this start
position as the origin, the scan AF processing is
10 executed until the group of focus lenses 3 reaches a
position C found by adding Gs to the result of distance
measurement of the active AF that is the end position
(steps S53 to S55). Then, on the basis of an AF
evaluation acquired by this, the CPU 15 performs an
15 arithmetic operation for obtaining a focus position
(step S56). According to this arithmetic operation, a
position of D in FIG 8, which is a position of the
group of focus lenses 3 corresponding to a peak value
of a high-frequency component, is found as the focus
20 position. Thereafter, the CPU 15 drives the group of
focus lenses 3 to that position (step S57).

In this way, the CCD 5 is used as a light-
receiving unit in the active AF, a distance to the
object is roughly calculated from outputs of a
25 plurality of pixel columns thereof, and a position of
the group of focus lenses 3, where a high-frequency
component to be outputted is the largest, is found from

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image signals generated by the CCD 5 while moving the group of focus lenses 3 in a range set around a position corresponding to the roughly calculated distance, whereby the scan AF processing for detecting

5 an accurate focus position is performed. Consequently, it is made possible to detect a focus position at high speed and accurately with a low-cost structure simply added with the light-emitting section for floodlighting an infrared ray.

10 [Second embodiment]

Next, a second embodiment of the present invention will be described.

A basic constitution of an image sensing apparatus and its basic operation procedure according to the

15 second embodiment are the same as the first embodiment. However, a method of detecting an object in the active AF is different from the method that is described with reference to FIGS. 4 and 5 in the first embodiment. Thus, the method will be described.

20 In the active AF in the second embodiment, detection of an object is performed in a plurality of rows, and a most appropriate object is selected out of obtained objects. In addition, as in the first embodiment, only pixels corresponding to red of a color

25 filter having highest sensitivity to an infrared ray are used.

Processing for extracting a reflected image and
calculating a center of gravity thereof, which is
performed in step S28 of FIG. 3, will be hereinafter
described with reference to FIGS. 9 and 10. Here, an
5 object with a relatively high luminance having steep
leading and trailing edge is extracted, and a center of
gravity of the extracted object is found.

First, in step S800, the CPU 15 performs
initialization of variables used in an arithmetic
10 operation and initialization of a work area of a memory.
Here, the CPU 15 clears a work area in which counters i,
j, and k and data of an object are to be stored. In
addition, since a plurality of objects may be detected,
a plurality of memory areas for an arithmetic operation
15 are prepared in which data of the objects is stored.

Next, in step S801, the CPU 15 reads out the
differential data stored in the memory incorporated in
the CPU 15 in order. Here, each data is represented as
$d[i,j]$. Then, in step S802, the CPU 15 compares $d[i,j]$
20 with the first threshold value Th1. If $d[i,j]$ is equal
to or more than the first threshold value Th1, in step
S803, the CPU 15 calculates a difference between $d[i,j]$
and differential data of a pixel that is away from the
pixel of $d[i,j]$ by a plurality of pixels (e.g., four
25 pixels), and checks if the difference is equal to or
more than a second threshold value Th2. If the
difference is equal to or more than the second

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threshold value Th2, since it can be judged as a

leading edge of an object (i.e., a left end of the

object), the process proceeds to step S804 and stores

various data of this object in the memory incorporated

5   in the CPU 15. Consequently, an object with a

relatively high luminance having steep leading edge has

been detected. On the other hand, if the condition is

not satisfied in step S802 or S803, the process

proceeds to step S822 in FIG. 10.

10   In step S804, the CPU 15 finds a sum of luminance

d[i,j] of signals and a sum of products of luminance of

signals and coordinates, d[i,j]×i and d[i,j]×j, as data

of the object and stores the sums. In addition, the

CPU 15 stores j as L_work as a coordinate of the left

15   end of the object. Now, when it is assumed that a sum

of luminance of the object is Sd_work and a sum of

products of luminance and coordinates is Se_work, the

following equations are used.

Sd_work = d[i,j]

20   Se_work = d[i,j]×i

In step S805, the CPU 15 increments the counter j

by two to set a differential data value of the next

pixel corresponding red of a color separation filter as

a subject of processing. In the next step S806, the

25   CPU 15 judges if the value of the counter j indicates a

coordinate of a pixel outside the detection area. If

the value indicates a coordinate of a pixel outside the

detection area, the process proceeds to step S824, and if the value indicates a coordinate of a pixel within the detection area, the process proceeds to step S807. In step S806, the CPU 15 reads out the differential

5   data d[i,j] stored in the incorporated memory. Then, in step S808, the CPU 15 compares d[i,j] with the first threshold value Th1. If d[i,j] is equal to or more than the first threshold value Th1, since the object still continues, the process proceeds to step S809 and

10   updates the data of the object in accordance with the following equations.

$$Sd\_work = Sd\_work+d[i,j]$$

$$Se\_work = Se\_work+d[i,j] \times i$$

The CPU 15 performs these processes for updating

15   data of the object until the condition of step S808 are not satisfied while updating the counter j in step S805. However, if the detection for all the pixels is finished while thes processes are continued (YES in step S806), since the condition of trailing edge is not

20   satisfied, the CPU 15 judges that the object currently detected is inappropriate, does not perform the processing for storing data of the object stored in the work area to that point in the storage area, and the pocess immediately proceeds to step S824.

25   If the condition of step S808 is not satisfied (if data is not equal to or more than the first threshold value Th1), since it can be judged that the object has

ended, the CPU 15 checks whether or not the object has

a steep trailing edge. In step S810, the CPU 15

calculates a difference between d[i,j] and differential

data of a pixel that is away from the pixel of d[i,j]

5   by a plurality of pixels (e.g., four pixels), finds

inclination at the trailing edge of the object, and

checks if the inclination is equal to or more than the

second threshold value Th2. If the declination at the

trailing edge of the object is equal to or more than

10   the second threshold value Th2, since an object with a

relatively high luminance having steep leading and

trailing edges has been extracted, the CPU 15 stores j-

2 as R_work as a coordinate of the right end of the

object in step S811.

15   Then, the CPU 15 proceeds to step S812 and

performs processing for storing the data of the object

stored in the work area.

        On the other hand, if the condition is not

satisfied in step S810, since an object with a

20   relatively high luminance having steep leading and

trailing edges has not been extracted, the CPU 15 does

not store the data of the object stored in the work

area to that point in the storage area and the process

proceeds to step S822.

25   In step S812 and subsequent steps, the CPU 15

performs processing for storing the data of the object

stored in the work area.

In this processing, first, the CPU 15 checks whether or not an object, which is the same as the object stored in the work area, already exists.

In step S812, the CPU 15 checks a value of the counter k indicating the number of areas in which the data of the object has been stored to that point. If k is equal to zero, since the data of the object has not been stored to that point, the CPU 15 proceeds to processing of step S819 and subsequent steps for generating an area for a new object and storing the data. This processing will be described later.

If k is not equal to zero, the CPU 15 initializes a value of the counter m to one in step S813 and sequentially checks the areas from the area in which the first object is stored. In step S814, the CPU 15 compares a value L[m] of the left end of object data stored in an m-th storage area and a value L_work of the left end of object data stored in the work area. If these values are substantially the same, the process proceeds to step S815. Subsequently, in step S815, the CPU 15 compares a value R[m] of the right end of the object data stored in the m-th storage area and a value R_work of the right end of the object data stored in the work area. If the values are substantially the same, the process proceeds to step S816. In step S816, the CPU 15 checks if a value D[m] at the lower end of the object data stored in the m-th storage area and the

object of the work area are adjacent to each other in the vertical direction. If the vertical direction coordinate i at the time when the data of the work area is detected is D[m]+2, the value D[m] and the object

5 are adjacent to each other. In this case, since it can be judged that both of them are the same object, the process proceeds to step S817 and the CPU 15 performs processing for storing the object data of the work area in the m-th storage area.

10 In step S817, the CPU 15 stores the data of the work area in the m-th storage area as indicated below.

Sd[m] = Sd[m]+Sd_work

Se[m] = Se[m]+Se_work

L[m] = Min(L[m],L_work)

15 R[m] = Max(R[m],R_work)

D[m] = i

Here, Sd[m] indicates a sum of luminance of signals, Se[m] indicates a sum of products of luminance of signals and horizontal direction coordinates, L[m]

20 indicates the coordinate of the left end of the object, R[m] indicates the coordinate o the right end of the object, and D[m] indicates the coordinate o the lower end of the object. In addition, Min(L[m],L_work) is an arithmetic operation for selecting a smaller one of L[m] and L_work, and Max(R[m], R_work) is an arithmetic

25 operation for selecting a larger one of R[m] and R_work. Consequently, outer coordinates can be stored as

coordinates at the left and right ends. In addition, a suffix m in the brackets represents a parameter in the m-th storage area.

If the condition is not satisfied in steps S814, S815, or S816, in step S818, the CPU 15 compares the counter m and the number of storage areas k to thereby check if the comparison with all the existing storage areas has been finished. If m is equal to k, since the comparison with all the storage areas has been finished, there is no object that is the same as the object stored in the work area. Thus, the CPU 15 proceeds to step S820 in order to generate a new storage area and store the object data of the work area in the new storage area.

If the comparison with all the storage areas has not been finished (if m<k), the CPU 15 increments the counter m by one in step S819, and then returns to step S814 and performs comparison with data of the next storage area.

In step S820, the CPU 15 increments a value of the counter k, which indicates the number of areas storing data of the objects, by one to increase the number of storage areas, and then proceeds to step S821, generates an area for storing data of a new object and stores the data. Storing in step S821 is performed as indicated below.

Sd[k] = Sd_work

```
      Se[k] = Se_work

      L[k] = L_work

      R[k] = R_work

      U[k] = i

5     D[k] = i
```

Here, Sd[k] indicates a sum of luminance of
signals, Se[k] indicates a sum of products of luminance
of signals and horizontal direction coordinates, L[k]
indicates the coordinate of the left end of the object,

10   R[k] indicates the coordinate of the right end of the
object, U[k] indicates the coordinate of the upper end
of the object, and D[k] indicates the coordinate of the
lower end of the object. In addition, a suffix k in
the brackets represents a parameter in the k-th storage

15   area.

Then, the process proceeds to step S822 and
increments the counter j by two to set the next pixel
corresponding to red of the color separation filter as
a subject of an arithmetic operation, and then, in step

20   S823, the CPU 15 checks whether or not processing for
all the pixels in the horizontal direction has been
finished. If the processing for all the pixels in the
horizontal direction has not been finished, the CPU 15
returns to step S801 and continues the processing.

25   If the detection for all the pixels in the
horizontal direction has been finished, in step S824,
the CPU 15 increments the counter i by two to set the

next row, on which a pixel corresponding to red of the color separation filter exists, as a subject of processing, and then, in step S825, checks whether or not processing for all the rows has been finished. If

5   the processing for all the rows in the vertical direction has not been finished, the CPU 15 initializes j in step S826, and then returns to step S801 and continues the processing.

If the detection for all the rows has been

10 finished, in step S827, the CPU 15 finds a center of gravity of the detected object. The coordinate Px of a center of gravity in the horizontal direction of the object is as indicated below.

Px = Se[m]/Sd[m]

15 In addition, since a center of gravity in the vertical direction is meaningless in the case of finding a distance to the object in the active AF processing, an arithmetic operation for finding the center of gravity in the vertical direction is not performed.

20   Further, when a plurality of objects have been detected, an object/objects for which both of R[m]-L[m] and D[m]-U[m] are within a predetermined range is/are selected. This is because, since a size of a reflected image of a light-emitting section 30 on the surface of

25 the CCD 5 should be substantially fixed, only reflected image/images falling within a fixed range anticipating an error is/are considered to be correct reflected

image/images of the light-emitting section 30. In the case in which a plurality of objects still remain, first, a difference between $(R[m]-L[m])$ and $(D[m]-U[m])$ is checked, and an object with the smallest difference

5 is selected. This is because, in the case in which a shape of a light-emitting section 30 is directly reflected and focused on the CCD 5, it is considered that sizes in the horizontal direction and the vertical direction thereof are substantially the same. However,

10 since an error due to a form of an object to be sensed, a reflectivity, or the like occurs, object/objects having the difference/differences within a predetermined range about the lowest difference is/are considered to have the substantially same lowest

15 difference between $(R[m]-L[m])$ and $(D[m]-U[m])$. Then, an object with a largest value of $Sd[m]/(R[m]-L[m])$ is selected out of the objects. An object with a largest value of $Sd[m]/(R[m]-L[m])$ is selected because, since external light elimination has been performed for the

20 object, it is considered that a luminance of a reflected image of a light-emitting section 30 becomes the maximum.

[Third embodiment]

Next, a third embodiment of the present invention

25 will be described.

A basis constitution of an image sensing apparatus and its basic operation procedure according to the

third embodiment are the same as the first embodiment.
However, a method of detecting an object in the active
AF is different from the method that is described with
reference to FIG. 4 in the first embodiment. Thus, the
5   method will be described.

In the active AF in the third embodiment,
detection of an object is performed using differential
data of one line, and a most appropriate object is
selected out of obtained objects.

10   Processing for extracting a reflected image and
calculating a center of gravity thereof, which is
performed in step S28 of FIG. 3, will be hereinafter
described with reference to FIGS. 11 and 5. Here, an
object with a relatively high luminance having steep
15   leading and trailing edges is extracted, and a center
of gravity of the extracted object is found.

First, in step S500, the CPU 15 performs
initialization of variables used in an arithmetic
operation and initialization of a work area of a memory.
20   Here, the CPU 15 clears a work area in which counters i
and k and data of an object are to be stored. In
addition, since a plurality of objects, which are
considered to be a reflected image, may be detected, a
plurality of memory areas for an arithmetic operation
25   are prepared in which data of the objects is stored.

Next, in step S501, the CPU 15 reads out
differential data of a predetermined row stored in the

memory incorporated in the CPU 15. A value of this
data is represented as d[i]. Then, in step S502, the
CPU 15 compares d[i] with the first threshold value Th1.
If d[i] is equal to or more than the first threshold

5   value Th1, in step S503, the CPU 15 calculates a
difference between d[i] and differential data of a
pixel that is away from the pixel of d[i] by a
plurality of pixels (e.g., two pixels), and checks if
the difference is equal to or more than a second

10 threshold value Th2. If the difference is equal to or
more than the second threshold value Th2, since it can
be judged as a leading edge of an object (i.e., a left
end of the object), the process proceeds to step S504
and various data of this object is stored in the memory

15 incorporated in the CPU 15. Consequently, an object
with a relatively high luminance having steep leading
edge has been detected. If the condition is not
satisfied in step S502 or S503, the process proceeds to
step S416 in FIG. 5.

20   In step S504, the CPU 15 finds a sum of luminance
d[i] of signals and a sum of products of luminance of
signals and coordinates, d[i] x i, as data of the
object and stores the sums. In addition, the CPU 15
stores i as L[k] as the coordinate of the left end of

25 the object. Now, when it is assumed that a sum of
luminance of a k-th object is Sd[k] and a sum of

products of luminance and coordinates is Se[k], the
following equations are used.

$$Sd[k] = d[i]+d[i-1]$$

$$Se[k] = d[i] \times i + d[i-1] \times (i-1)$$

5   In step S505, the CPU 15 increments the counter i
by one to set the next pixel as a subject of processing.
Then, in step S506, the CPU 15 judges if the processing
has been finished for all the pixels of the
differential data of the current row. If the
10   processing has been finished, the process proceeds to
step S510, and if the processing has not been finished,
the process proceeds to step S507. In step S507, the
CPU 15 reads out the next differential data d[i] stored
in the incorporated memory. Then, in step S508, the
15   CPU 15 compares the d[i] with the first threshold value
Th1. If d[i] is equal to or more than the first
threshold value Th1, since the object still continues,
the process proceeds to step S509 and updates the data
of the object in accordance with the following
20   equations.

$$Sd[k] = Sd[k]+d[i]$$

$$Se[k] = Se[k]+d[i] \times i$$

The CPU 15 performs these processes for updating
data of the object until the condition of step S508 are
25   not satisfied while updating the counter i in step S505.
However, if the detection for all the pixels is
finished while these processes are performed (YES in

step S506), since the condition of trailing is not satisfied, the CPU 15 judges that the object currently detected is inappropriate, clears the data of the object in step S510, and the process immediately

5 proceeds to step S418 of FIG. 5.

If the condition of step S508 is not satisfied (if d[i] is not equal to or more than the first threshold value Th1), since it can be judged that the object has ended, the CPU 15 checks whether or not the object has

10 a steep trailing edge. As shown in FIG. 5, in step S412, the CPU 15 calculates a difference between d[i] and differential data of a pixel that is away from the pixel of d[i] by a plurality of pixels (e.g., two pixels), finds inclination at the trailing edge of the

15 object, and checks if the declination is equal to or more than the second threshold value Th2. If the dclination at the trailing edge of the object is equal to or more than the second threshold value Th2, since an object with a relatively high luminance having steep

20 leading and trailing edges has been extracted, the process proceeds to step S413 and the CPU 15 updates the data of the object in accordance with the following equations.

$Sd[k] = Sd[k]+d[i]$

25 $Se[k] = Se[k]+d[i]×i$

Moreover, the CPU 15 stores i in R[k] as the coordinate on the right end of the object. Then, the

CPU 15 increments the counter k by one (step S414) and updates an address of the memory storing the data of the object. On the other hand, if the condition is not satisfied in step S412, since an object with a

5 relatively high luminance having steep leading and trailing edges has not been extracted, the CPU 15 clears the data of the object that has been stored to that point (step S415).

Then, the process proceeds to step S416 and the

10 CPU 15 increments the counter i by one to set the next pixel as a subject of an arithmetic operation, and then, in step S417, checks whether or not detection for all the pixels in the row has been finished.

If the detection for all the pixels in the row has

15 been finished, in step S418, the CPU 15 finds a center of gravity of the detected object. The coordinate Px of the center of gravity of the object is calculated as follows.

Px = Se[k]/Sd[k]

20 It should be noted that, when a plurality of objects have been detected, the CPU 15 selects object/objects for which R[k]-L[k] is within a predetermined range. This is because, since a size of a reflected image of a light-emitting section 30 on the

25 CCD 5 should be substantially fixed, only reflected image/images falling within a fixed range anticipating an error is/are considered to be correct reflected

image/images of the light-emitting section 30. In the case in which a plurality of objects still remain, an object for which a value of $Sd[k]/(R[k]-L[k])$ is the largest is selected. This is because, since the

5 external light elimination has been performed for the object, it is considered that a luminance of a reflected image of a light-emitting section 30 becomes the maximum.

Sensitivity to an infrared ray of each color of

10 the color separation filter arranged in front of the CCD 5 in detecting an object has been neglected. However, since there is a difference of sensitivity in practice, the processing for detection of an object is performed after correcting respective pixel data in

15 accordance with the sensitivity to an infrared light of each color of the filter, or as described in the first embodiment, only pixel data corresponding to red of a color filter having the highest sensitivity to an infrared ray are used.

20 In this way, the CPU 15 ends the processing for finding a center of gravity of a reflected image in the third embodiment and returns to step S28 of FIG. 3.

In addition, in the third embodiment, in performing the partial read-out processing in step S22

25 and storing the read-out partial image data in step S23 in the active AF processing shown in FIG. 3, an output of the A/D conversion circuit 7 is controlled to be

inputted to the CPU 15. Thus, the output of the A/D

conversion circuit 7 is not temporarily stored in the

VRAM 8. Thus, an image due to charge accumulation with

the light-emitting section 30 on is not displayed on

5   the LCD 10 and an image temporarily stored immediately

before that is displayed.

An image due to charge accumulation with the

light-emitting section 30 on is not displayed in order

to prevent an image causing a sense of incongruity from

10   being displayed on the LCD 10 due to the fact that only

a part of images are read out for speed-up of an

arithmetic operation and a reflected image of a light-

emitting device is imprinted. In addition, since an

image due to charge accumulation with the light-

15   emitting section 30 off performed in step S24 of FIG. 3

immediately after the charge accumulation with the

light-emitting section 30 on performed in step S21 of

Fig. 3 is displayed, a sense of incongruity such as a

freezing screen is not given to a user.

20   Note that, in the third embodiment, since only

differential data for one line is used, it is advisable

to control the partial reading performed in step S22 of

the active AF processing shown in FIG. 3 so as to read

out only a predetermined row used in the processing of

25   FIG. 11 rather than reading out an area (detection

area) in a central part as in the first embodiment.

[Fourth embodiment]

Next, a fourth embodiment of the present invention will be described.

A basis constitution of an image sensing apparatus and its basic operation procedure according to the
5   fourth embodiment are the same as the first embodiment. However, the fourth embodiment has a characteristic in image display control at the time of the active AF processing.

In the fourth embodiment, unlike the third
10   embodiment, image signals are stored in the VRAM 8 even at the time when a light beam is irradiated in the active AF. In that case, a flag indicating that the light beam is irradiated is set such that the image signals stored in the VRAM 8 are not outputted to the
15   D/A conversion circuit 9 in a state in which this flag is set. With such control, an image sensed at the time when a light beam is irradiated is not displayed on an image display apparatus.

Details of the display control will be hereinafter
20   described with reference to FIG. 12.

First, in step S70, the CPU 15 drives the filter drive circuit 33 to retract the iR cut filter 32 from the front of the CCD 5 so as not to attenuate an infrared ray component that is attenuated at the time
25   of image sensing. This is because an infrared light-emitting device is used as a light-emitting section 30 for the active AF processing since reflectance of an

infrared ray on various objects is more stable than a
normal ray and good distance measurement can be
expected.

Subsequently, in step S71, the CPU 15 performs
5   charge accumulation with the light-emitting section 30
on. The CPU 15 causes the light-emitting section 30 to
emit light to irradiate an infrared ray to the object.
At the same time, the CPU 15 adjusts an amount of light
to be received by the CCD 5 with the stop 4. More
10   specifically, the CPU 15 performs control such that the
stop 4 is narrowed and an amount of light emission of
the light-emitting section 30 is increased when it is
bright and the stop 4 is opened and the amount of light
emission of the light-emitting section 30 is reduced
15   when it is dark. Thereafter, in step S72, the CPU 15
sets a flag for prohibiting output of image signals
from the VRAM 8 to the D/A conversion circuit 9.

Next, in step S73, a signal obtained by the charge
accumulation with the light-emitting section 30 on is
20   stored in the VRAM 8 by hardware means according to an
instruction from the CPU 15. More specifically, a
received image of the object is converted into electric
signals by the photoelectric conversion processing of
the CCD 5 and outputted to the image sensing circuit 6.
25   In the image sensing circuit 6, various kinds of signal
processing are applied to the inputted signal to
generate image signals. These image signals are

outputted to the A/D conversion circuit 7 and converted

into digital signals (image data), and are then

temporarily stored in the VRAM 8. However, the image

data temporarily stored in the VRAM 8 is not outputted

5   to the D/A conversion circuit 9. In this case, since

the LCD 10 is driven in accordance with data which was

set immediately before this image data is stored, the

image due to the charge accumulation with the light-

emitting section 30 on is not displayed on the LCD 10,

10   and an image acquired immediately before that continues

to be displayed.

Next, the process proceeds to step S74 and the CPU

15 performs charge accumulation with the light-emitting

section 30 off with the same stop as at the time of the

15   charge accumulation with the light-emitting section 30

on in step S71. Simultaneously with this accumulation

which is, before outputting signals from the CCD 5 to

the image sensing circuit 6, the CPU 15 reads out only

a part of the image data, which corresponds to a

20   central part of the output signal from the CCD 5, from

the VRAM 8 and stores it in the incorporated memory.

This is because, since the CPU 15 only has to store a

part, on which a reflected image from a subject is

formed, an amount of data is small. In addition,

25   speed-up of processing can be expected by performing

transfer of data during the charge accumulation with

the light-emitting section 30 off. However, in the

case in which the charge accumulation with the light-emitting section 30 off ends before the transfer from the VRAM 8 to the memory incorporated in the CPU 15 because the object to be sensed is extremely bright,

5   the charge accumulation with the light-emitting section 30 off is performed after the transfer from the VRAM 8 to the memory incorporated in the CPU 15 ends.

Next, in step S75, the signal obtained in the charge accumulation with the light-emitting section 30

10   off is stored in the VRAM 8 by the hardware means according to an instruction from the CPU 15. After an amount of light from the object to be sensed is adjusted by the stop 4, the image formed on the light-receiving surface of the CCD 5 is converted into

15   electric signals by the photoelectric conversion processing by the CCD 5 to be outputted to the image sensing circuit 6. In the image sensing circuit 6, various kinds of signal processing are applied to the inputted signals, and image signals of a predetermined

20   form are generated. These image signals are outputted to the A/D conversion circuit 7 and converted into digital signals (image data), and are then temporarily stored in the VRAM 8.

Then, in step S76, the flag prohibiting transfer

25   of image signals from the VRAM 8 to the D/A conversion circuit 9 is cleared. The image signals read out from the VRAM 8 are converted into analog signals by the D/A

conversion circuit 9 and converted into image signals of a form suitable for display, and are then displayed as an image on the LCD 10.

The process proceeds to step S77 and the CPU 15

5   performs an external light eliminating operation. Here, the CPU 15 finds a difference between image data of the charge accumulation with the light-emitting section 30 on and image data of the charge accumulation with the light-emitting section 30 off to thereby find data

10   (object) of a reflected image obtained as an infrared ray irradiated from the light-emitting section 30 is reflected on the object. Since a component of an image formed by external light can be removed, it becomes easy to find a center of the reflected image.

15   practically, the CPU 15 reads data of a part corresponding to the image data stored in the memory incorporated in the CPU 15 among the image data stored in the VRAM 8 and calculates differences between the read data and the image data stored in the memory

20   incorporated in the CPU 15 to thereby perform external light elimination. A result of the arithmetic operation (differential data) with the external light eliminated in this way is stored in the memory incorporated in the CPU 15.

25   Subsequently, in step S78, the CPU 15 extracts a reflected image and calculates a center of gravity thereof. The CPU 15 extracts an object with a

relatively high luminance having steep leading and

trailing edges, and finds a center of gravity of the

extracted object. Since this processing may be the

processing described in any one of the first to third

5   embodiments, the description of the processing will be

omitted. Then, in step S79, the CPU 15 finds a

distance to the object from a position of the center of

gravity of the reflected image in the same manner as

the processing performed in step S29 of FIG. 3.

10   Thereafter, the process proceeds to step S80 and

inserts the iR cut filter 32, which was retracted from

the front of the CCD 5 in step S70, in front of the CCD

5 again.

[Fifth embodiment]

15   Next, a fifth embodiment of the present invention

will be described.

In the fifth embodiment of the present invention,

a VRAM 80, which stores image signals obtained at the

time when a light beam is irradiated in the active AF,

20   is provided anew, and image signals obtained at the

time when a light beam is irradiated by the light-

emitting section 30 are stored in the VRAM 80. Since

this VRAM 80 is not connected to the D/A conversion

circuit 9, an image sensed at the time when a light

25   beam is irradiated is not displayed on an image display

apparatus.

A basic structure of an image sensing apparatus according to the fifth embodiment is shown in FIG. 13. The fifth embodiment is different from the first to fourth embodiments only in that the VRAM 80, which

5 stores image signals obtained at the time when a light beam is irradiated, is provided anew. IA basic operation procedure is the same as the first embodiment except that processing is performed using the VRAM 80 in the active AF. An operation of the active AF in the

10 fifth embodiment will be hereinafter described with reference to FIG. 14.

First, in step S90, the CPU 15 drives the filter drive circuit 33 to retract the iR cut filter 32 from the front of the CCD 5 so as not to attenuate an

15 infrared ray component that is attenuated at the time of image sensing. This is because an infrared light-emitting device is used as a light-emitting section 30 for the active AF processing since reflectance of an infrared ray on various objects is more stable than a

20 normal ray and good distance measurement can be expected.

Subsequently, in step S91, the CPU 15 performs charge accumulation with the light-emitting section 30 on. The CPU 15 causes the light-emitting section 30 to

25 emit light to irradiate an infrared ray to the object. At the same time, the CPU 15 adjusts an amount of light to be received by the CCD 5 with the stop 4. More

specifically, the CPU 15 performs control such that the stop 4 is narrowed and an amount of light emission of the light-emitting section 30 is increased when it is bright and the stop 4 is opened and the amount of light

5   emission of the light-emitting section 30 is reduced when it is dark. The incident optical image of the object is converted into electric signals by the photoelectric conversion processing of the CCD 5 and outputted to the image sensing circuit 6.

10   Next, in step S92, the CPU 15 controls the image sensing circuit 6 to read out the electric signals only from a detection area corresponding to a central part of the output signal from the CCD 5. In the image sensing circuit 6, various kinds of signal processing

15 are applied to the inputted signals to generate image signals of a predetermined form. These image signals are outputted to the A/D conversion circuit 7 and converted into digital signals (image data), and are then temporarily stored in the VRAM 80. Speed-up of

20 processing can also be realized by reading only a part in this way. Since the VRAM 80 is not connected to the D/A conversion circuit 9, an image obtained at the time of the charge accumulation with the light-emitting section 30 on is not naturally displayed on the LCD 10.

25 An image, which has been displayed immediately before this image data acquisition continues to be displayed on the LCD 10. With such display control, it is

possible to prevent an image causing a sense of incongruity from being displayed on the LCD 10 due to the fact that only a part of image signals are read out for speed-up of an arithmetic operation and a reflected

5   image of a light-emitting device is imprinted. In addition, since an image due to charge accumulation with the light-emitting section 30 off performed in step S94 of FIG. 14 immediately after the charge accumulation with the light-emitting section 30 on

10   performed in step S91 is displayed, a sense of incongruity such as a freezing screen is not given to a user.

The process proceeds to step S93 and the CPU 15 performs the charge accumulation with the light-

15   emitting section 30 off with the same stop as at the time of the charge accumulation with the light-emitting section 30 on in step S21. The optical image of the object formed on the light receiving surface of the CCD 5, after an amount of light thereof is adjusted by the

20   stop 4, is converted into electric signals by the photoelectric conversion processing of the CCD 5 and outputted to the image sensing circuit 6. In the image sensing circuit 6, various kinds of signal processing are applied to the inputted signals to generate image

25   signals. These image signals are outputted to the A/D conversion circuit 7 and converted into digital signals (image data), and are then temporarily stored in the

VRAM 8. Then, the image signals are outputted to the
D/A conversion circuit 9, converted into analog signals
and converted into image signals of a form suitable for
display, and are then displayed as an image on the LCD
5   10.

Next, the process proceeds to step S94 and
performs an external light eliminating operation. Here,
the CPU 15 finds differences between image data of the
charge accumulation with the light-emitting section 30
10 on and image data of the charge accumulation with the
light-emitting section 30 off to thereby find data of a
reflected image obtained as a light beam irradiated
from the light-emitting section 30 is reflected on the
subject. Since component of an image formed by
15 external light can be removed, it becomes easy to find
a center of the reflected image.

Practically, the CPU 15 calculates differences
between the image data stored in the VRAM 80 and the
image data stored in the VRAM 8 to thereby perform
20 external light elimination. More specifically, the CPU
15 subtracts the image data, which corresponds to the
data stored in the VRAM 80, stored in the VRAM 8 from
the image data of the VRAM 80 and sequentially stores
values the differences in the memory incorporated in
25 the CPU 15. In this way, transfer in terms of hardware
with which transfer of data is performed at high speed
is increased, and data transfer in terms of software is

reduced, whereby speed-up of an arithmetic operation can be expected.

Subsequently, in step S95, the CPU 15 extracts a reflected image and calculates a center of gravity

5   thereof. The CPU 15 extracts an object with a relatively high luminance having steep leading and trailing edges and finds a center of gravity of the extracted object. Since this processing may be the processing described in any one of the first to third

10   embodiments, the description of the processing will be omitted. Then, in step S96, the CPU 15 finds a distance to the object from a position of the center of gravity of the reflected image in the same manner as the processing performed in step S29 of FIG. 3.

15   Thereafter, the process proceeds to step S97 and the CPU 15 inserts the iR cut filter 32, which was retracted from the front of the CCD 5 in step S90, in front of the CCD 5 again.

The present invention is not limited to the above

20   embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore to apprise the public of the scope of the present invention, the following claims are made.

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